Lyctine susceptibility of selected hardwoods

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Summary

The lyctine susceptibility of 16 timber species, hybrids and geographical types was examined in this study. Several of the timbers had been placed previously in a ‘rarely susceptible’ category, but such uncertain ratings are not acceptable for standards and compliance purposes. Timber specimens were exposed to three species of lyctine beetles in an insectary. New criteria were developed to divide the problematic ‘rarely susceptible’ species, including designating a species as non-susceptible if significant damage was limited to 6 mm depth, as this outer region is routinely lost upon sawing or peeling. Lyctine-susceptible species were *Erythrophleum chlorostachys, Eucalyptus delegatensis* grown in Tasmania but not Victoria or NSW, *Eu. regnans* × *Eu. obliqua* hybrid, *Corymbia nesophila*, *Eu. fibrosa*, *Eu. grandis*, *Eu. crebra*, *Eu. argophloia*, *Eu. dunnii*, *Eu. regnans* from Tasmania and *Eu. saligna*. *Eu. grandis* × *Eu. saligna* hybrid is probably lyctine-susceptible as both parent species were susceptible. The non-lyctine-susceptible species were *Eu. cloeziana*, *Eu. pilularis*, *Eu. sieberi* and *Eu. tetradonta*.

Keywords: hardwoods; sapwood; wood borers; lyctine; *Lyctus*; *Lyctus brunneus*; *Minthea rugicollis*; *Lyctus discedens*; *Eucalyptus*; *Erythrophleum*; *Corymbia*

Introduction

The sapwood of certain hardwoods is susceptible to lyctine beetle damage. The significance of the damage varies according to the proportion of sapwood present in the timber piece. If the sapwood band is thin, then a small amount of damage in a structural member may be tolerated. In New South Wales (NSW) and Queensland, however, where there is a history of using hardwood species with thick bands of sapwood, state legislation constrains the sale and use of lyctine-susceptible timber. Similarly, even minor damage to appearance-grade products such as flooring and furniture can be unacceptable and lyctine-susceptible sapwood is not permitted by AS 2796.2-2006 (Standards Australia 2006). Susceptible timbers therefore require some form of preservative treatment to enable greater sawn recovery and utilisation of the hardwood resource.

Most studies on lyctine susceptibility were conducted from the 1940s to 1970s on mature trees that were more than 80 y old (CSIRO 1950; Fairey 1975). Lyctine susceptibility can vary with forest location and tree age. For example, *Eucalyptus delegatensis* (alpine ash) from Victoria is said to be non-susceptible, while the same species from Tasmania and NSW has been reported with varying degrees of susceptibility (Fairey 1975). Creffield *et al.* (1995) showed differences in susceptibility between samples of some regrowth and old-growth Western Australian hardwood species. More recently, Peters *et al.* (2002) reviewed the biology and behaviour of *Lyctus brunneus* and provided guidelines on methods for determining lyctine susceptibility.

Significant savings can accrue from using species or timber sources shown to have non-susceptible sapwood. Treatment costs can be avoided and the timber will be preservative-free. The main nutrient for lyctines is starch, which the tree produces to store energy. Starch content can vary with season. In cool temperate regions, starch usually accumulates over winter, but at other times concentrations may be below that needed to support the successful development of lyctines.

A key aim of the current research was to give more detailed information on a number of ‘borderline’ timber species that historically have been termed ‘rarely susceptible’. As the state acts of Queensland (*Timber Utilisation and Marketing Act 1987*, TUMA) and NSW (*Timber Marketing Act 1977*, TMA), and AS 5604-2005 (Standards Australia 2005b) recognise only susceptible or non-susceptible categories (and provide clear guidance on whether to treat the timber with preservatives), better information was needed on how to classify these borderline species.

The test timbers were exposed to three lyctine beetle species: *Lyctus brunneus* which is found Australia wide, and the smaller species *L. discedens* and *Minthea rugicollis.* Results from these bioassays are presented and the implications for industry are discussed in this paper.

Materials and methods

While Peters *et al.* (2002) described the preferred steps in lyctine testing, resource restrictions for this project necessitated some short-cuts and variations, as indicated in this section.

Timber sources

The timber species examined were:

Corymbia nesophila (Melville Island bloodwood) from Cape York, Queensland

Erythrophleum chlorostachys (Cooktown ironwood) from Cape York, Queensland
Eucalyptus argophloia (western white gum) from Queensland
Eucalyptus cloeziana (Gympie messmate) from Queensland
Eucalyptus crebra (narrow-leaved red ironbark) from NSW
Eucalyptus delegatensis (alpine ash) from Tasmania, Victoria and one collection from NSW
Eucalyptus dunnii (Dunn's white gum) from NSW and Queensland
Eucalyptus fibrosa (broad-leaved red ironbark) from NSW
Eucalyptus grandis (rose gum) from NSW
Eucalyptus pilularis (blackbutt) from NSW
Eucalyptus regnans (mountain ash) from Tasmania
Eucalyptus regnans × *Eu. obliqua* hybrid from Tasmania
Eucalyptus saligna (Sydney blue gum) from NSW
Eucalyptus sieberi (silvertop ash) from Victoria
Eucalyptus tetradonta (Darwin stringybark) from Cape York, Queensland

Efforts to obtain authentic *Eu. grandis* × *Eu. saligna* hybrid were unsuccessful.

The initial plan was for forestry collaborators to supply samples containing sapwood at three-monthly intervals for two years or until there was earlier demonstration of lyctine susceptibility (Peters *et al*. 2002). At each sampling, five trees were to be sampled from three to four regions throughout the natural distribution of regrowth or plantation for each timber species. Regrowth timber from trees in the 25–50-y age group was targeted as being more representative of the future timber supply than samples from old-growth trees. Younger trees were examined when the 25–50-y age group was not available. One problem encountered with tree sampling was that the number of samples and the geographical distribution sought were difficult to achieve for some species. For example, mature trees of Western white gum (*Eu. argophloia*) are relatively rare, and most occur in reserves, so that the level of sampling desired was not possible. The Victorian alpine fires in early 2003 also rendered some sites for collection of *Eu. delegatensis* unsuitable for the trial. At other times it was difficult for cooperating agencies to roster staff to the project in the face of competing demands and organisational changes. Nevertheless in total 777 test specimens, representing 772 different trees, were examined.

Sapwood samples, with heartwood attached, were cut at breast height as a disc from felled trees (within 48 h of felling). Bark was removed immediately in the field and the sample forwarded to CSIRO for air drying. Timber was stored indoors and uncovered, to avoid mould growth.

Prior to bioassay, the sapwood was spot tested for starch using an iodine indicator as described in Australian Standard 1604.1-2005 (Standards Australia 2005a). The timber was then cut to obtain heartwood–sapwood test specimens with dimensions greater than 100 mm long × 25 mm wide × full sapwood depth. Test specimens were cut using a tungsten-tipped saw, to prevent burring and the blocking of vessels (which may inhibit lyctine oviposition). All test specimens, regardless of the result of the starch test, were subjected to lyctine bioassay. With each round of bioassay, jars containing untreated sapwood samples of black bean (*Castanospermum australe*) were also prepared as a check on the viability of the lyctine test cultures.

Peters *et al*. (2002) suggested that a starch test should be used in the field to determine which timbers to test against lyctines. For this project, however, all timber samples collected were placed into bioassay, for two reasons:

- As timber was being collected by many different collaborators it was not certain that the starch test would be used and interpreted consistently, which could have lead to some bias in the selection of samples to be tested.
- Most timber species to be examined in this work were in the previously-assigned 'rarely susceptible' category and as a consequence we believed that assessment of starch alone may not have been a reliable indicator of susceptibility of these species.

Another departure from Peters *et al*. (2002) is that the diameter of pores in test samples was not determined. Most *Eucalyptus* species have mean pore diameters greater than the 70 µm threshold for lyctine susceptibility — 46 out of 50 *Eucalyptus* species examined by Bamber and Erskine (1965) had mean pore diameters > 70 µm. Therefore effort was directed towards the bioassay of every test specimen as the final arbiter on lyctine susceptibility.

Lyctine bioassays

The test specimens including black bean were heated at 60°C overnight to kill any mites that might be present on the received timber samples. They were then equilibrated in a conditioned insectary at 26°C and 70% relative humidity for seven days prior to inoculation with test insects. Each test specimen was exposed to not less than 20 unsexed adult beetles of each species of lyctine (*Lyctus brunneus*, *L. discedens* and *Minthea rugicollis*). Three lyctine species rather than *L. brunneus* alone (Peters *et al*. 2002) were used in the bioassay. This was to avoid any problem arising from variations between beetle species that might have affected results for the 'rarely susceptible' timbers. Inoculation with the lyctine species occurred consecutively, each lyctine species inoculation being separated by two weeks or more. For each lyctine species, a second inoculation of 20 unsexed adult beetles was made three weeks after the first inoculation. Therefore, test specimens were inoculated on six different occasions. The duration of the tests was at least three months from the time of the last inoculation.

Ratings

The test specimens were assessed by splitting them longitudinally and evaluating any larval channelling thereby revealed, using the following subjective rating system (Creffield *et al*. 1995; Peters *et al*. 2002):

- NS: non-susceptible — no channelling
- S1: slightly susceptible — small amount of larval channelling, sometimes only 10 mm in length along the vessel. Emergence holes absent, and frass not expelled from wood
- S2: moderately susceptible — moderate amount of larval channelling
- S3: highly susceptible — large amount of larval channelling. Broad frass-packed larval galleries.

Results and discussion

Criteria for susceptibility

In this work a species was considered to be non-susceptible when all test specimens lacked larval channelling. Further, species of which a minor percentage of test specimens rated no more than S1 were considered non-susceptible. The S1 rating is light damage, with no frass discharge from the test specimen and no emergence holes, indicating that the lyctines had insufficient starch to continue development and had died. They could not re-infest the original host specimen nor extend their activity to new wood.

The S1 ratings were often evident only under magnification and would be largely unnoticeable in service. We also found that if a timber species had only S1 damage the percentage of test specimens damaged was also small. For example, the worst rating we gave to any sample of *Eu. tetradonta* was S1, and this rating applied to only 3% of test specimens.

Timber species where any replicate had S2 (moderate) or S3 (heavy) damage through most of the sapwood were considered susceptible (with the following caveat), even if only one or a few replicates were involved. The caveat is that if the S2 or S3 damage was confined to the outer 6 mm of sapwood (and the remainder of the sapwood was not damaged or had S1 damage only), the timber was considered non-susceptible. During normal sawmilling, at least the outer 6 mm of sapwood is lost due to kerf and the need to have some wood on either side of the blade to provide stability during sawing. Similarly, when logs are peeled to produce veneer, the outer 10–15 mm (three log revolutions) is usually removed to waste (S. Dorries, PAA Newstead, 2007 *pers. comm.*). For these examples, iodine tests usually confirmed that significant starch was present only in the outer sapwood bands. It would be useful to verify the consistency in industry of the depth of these sapwood losses during machining. Our finding that susceptibility in some timber species can vary according to sapwood depth may account for some of the discrepancies in the rating of certain species by previous studies. Likewise, sawmills experiencing problems of differing lyctine susceptibility of the same timber species may be routinely removing varying depths of outer sapwood during conversion. Details on the depth of damage to each test specimen can be found in Cookson *et al*. (2007).

Susceptibility results

The highly lyctine-susceptible species, *C. australe*, was included in the bioassays to check that the lyctine beetles were active. Of the 78 *C. australe* test specimens exposed, one had no damage, nine had slight (S1) damage, five had moderate (S2) damage and 63 were heavily damaged (S3), confirming the viability of the lyctine beetles used in the project. The source billet of the *C. australe* samples that had little or no damage was checked and found to contain little starch.

The number of samples received of each timber species is shown in Table 1. Also shown is whether most trees came from plantations or natural regrowth.

The results of the lyctine bioassays are shown in Table 1, along with the recommended susceptibility ratings resulting from this work. Further discussion of the suggested ratings of some of the species follows:

- *Eucalyptus delegatensis* grows in the colder regions of Tasmania, Victoria and south-eastern NSW (Bootle 2005). In

Table 1. Lyctine susceptibility results and suggested ratings

Timber species and source details[a]	Number of test specimens	Fraction with any damage (%)	Fraction with S2 or S3[b] damage deeper than 6 mm (%)	Suggested rating[c]
Er. chlorostachys (PY)	46	100	91	S
Eu. saligna (R)	2	100	100	S
Eu. delegatensis, Tas (R)	40	58	52	S
Eu. regnans × *Eu. obliqua*, Tas (R)	28	57	46	S[d]
C. nesophila (PY)	67	54	25	S
Eu. fibrosa (R)	18	61	17	S[d]
Eu. grandis (PR)	52	37	10	S[d]
Eu. crebra (RP)	40	55	8	S[d]
Eu. argophloia (PRY)	39	15	8	S[d]
Eu. dunnii (PY)	21	43	5	S
Eu. regnans, Tas (R)	24	17	4	S[d]
Eu. delegatensis, mainland (RO)	55	16	0	NS[d]
Eu. pilularis (PR)	89	11	0	NS
Eu. sieberi (R)	91	8	0	NS
Eu. tetradonta (PY)	135	3	0	NS[d]
Eu. cloeziana (PY)	25	0	0	NS

[a]Tas = trees from Tasmania; P = plantations, R = natural regrowth, with main type listed first; Y = some trees < 20 y old, O = some trees 50–70 y old
[b]See text for explanation of S2 and S3
[c]S = susceptible, NS = non-susceptible
[d]Differs from AS 5604-2005, or was not listed

NSW, the species is confined to the southern tablelands and grows best around Batlow and Tumbarumba (Bootle 1971) (Fig. 1). The appearance of bark, leaves and fruit of Tasmanian *Eu. delegatensis* differs from that of the mainland population of the species (Boland *et al*. 1984). CSIRO (1950) listed alpine ash (*Eu. gigantea* = *Eu. delegatensis*) as rarely susceptible, but the source of the trees that were the basis of this assessment was not specified. In further research, Fairey (1975) noted that *Eu. delegatensis* grown in Victoria was not susceptible, that trees from NSW were rarely susceptible and that Tasmanian-grown material was susceptible. The current lyctine bioassay results support the view that mainland and Tasmanian populations are different, as Tasmanian *Eu. delegatensis* was readily damaged, whereas using the new criteria suggested here, Victorian-grown material should remain listed as non-susceptible. Only five trees from NSW were sampled, and all were non-susceptible. Due to close proximity (Fig. 1), NSW- and Victorian-grown *Eu. delegatensis* probably mix genetically and could be considered the one population. Therefore, based on existing information, mainland-grown *Eu. delegatensis* should be considered non-susceptible, while Tasmanian-grown *Eu. delegatensis* is susceptible.

- *Eucalyptus regnans* grows naturally in the mountainous regions of Tasmania and eastern Victoria (Bootle 2005), while *Eu. obliqua* (messmate) also grows in Tasmania, Victoria and the tableland districts of NSW and southern Queensland (Bootle 2005). *Eu. obliqua* is known to be lyctine susceptible (AS 5604-2005). The *Eu. regnans* × *Eu. obliqua* hybrid came from Tasmania where the appearance of the tree closely resembles that of *Eu. regnans* (P. Bennett, FIAT Hobart, 2006 *pers. comm.*), while anatomically the timber looks more like *Eu. obliqua* (J. Ilic, CSIRO Clayton, 2006 *pers. comm.*). Boland *et al*. (1984) noted that 'in southern Victoria and parts of Tasmania gum-topped forms intermediate between *Eu. regnans* and *Eu. obliqua* are not uncommon'. The method used to collect samples of *Eu. regnans* rather than hybrids for the current study was to obtain the material from higher altitudes (where *Eu. obliqua* does not occur) in areas regenerated after wildfire without supplementary aerial sowing (P. Bennett, FIAT Hobart, 2006 *pers. comm.*). The bioassay found that 46.4% of hybrid test specimens from Tasmania had lyctine damage, while only one test specimen (4.2% of those collected) of *Eu. regnans* from Tasmania had significant (S3) damage. Results were sufficient to consider both timbers lyctine susceptible, although further study on the differences between these timbers seems warranted. Note that *Eu. regnans* from the mainland is non-susceptible (as for *Eu. delegatensis*). Potentially, non-susceptible *Eu. regnans* could be distinguished and also separated from hybrid material at the sawmill by testing logs for the presence of starch.
- *Eucalyptus argophloia* grows naturally in a small area north-east of Chinchilla in south-eastern Queensland, from Burncluith to Burra Burri (Boland *et al*. 1984). It is a potential plantation species for Queensland and parts of NSW, and its lyctine susceptibility is not listed in AS 5604-2005. No specimens from 25–50-y old trees of *Eu. argophloia* from Queensland collected on three separate occasions were lyctine susceptible, which supports the finding from the iodine test that these specimens had starch contents that were low or not detectable. However, many test specimens from young plantations (trees 8 and 12 y old) had medium or high starch contents and several were lyctine susceptible. It is not known if this difference is due to tree age, different growing locations or month of collection.
- *Eucalyptus grandis* grows naturally along the east coast of NSW from the Hunter River to northern Queensland (Bootle 2005). It has been listed in AS 5604-2005 as not susceptible to lyctines. CSIRO (1950) considered that *Eu. grandis* was rarely susceptible, as did Fairey (1975). Only 5 out of 52 specimens (9.6%) of *Eu. grandis* had significant S2 or S3 damage, yet this is sufficient to consider the species lyctine susceptible. There appears to be some potential for avoiding lyctine-susceptible sapwood in this species by selecting the month of harvest. The highest proportion of susceptible *Eu. grandis* specimens was harvested in September, although some level of susceptibility continued for the remaining months and into February (Fig. 2). Humphreys and Humphreys (1966) found that the starch content of *Eu. grandis* also peaked in spring and early summer. We attempted to investigate the susceptibility of hybrid *Eu. grandis* × *Eu. saligna* but unfortunately authentic hybrid samples could not be obtained. Nevertheless, as *Eu. grandis* has been shown here to be susceptible and *Eu. saligna* has even greater susceptibility, it is likely that the hybrid would follow suit and, without further information, should be considered susceptible.
- *Eucalyptus tetradonta* grows naturally in the northern and northern coastal regions of the Northern Territory, the Kimberley region of Western Australia, and Cape York Peninsula (Bootle 2005). Most of this distribution is north of 17°S latitude (Boland *et al*. 1984). It is being grown as a plantation species in Cape York and, in an Aboriginal community enterprise, is being salvaged from rehabilitated mine sites. While AS 5604-2005 lists *Eu. tetradonta* as lyctine susceptible, it should be noted that this rating arose from an earlier interpretation of the current results when it was assumed that even limited S1 damage could be used to classify a timber as susceptible.

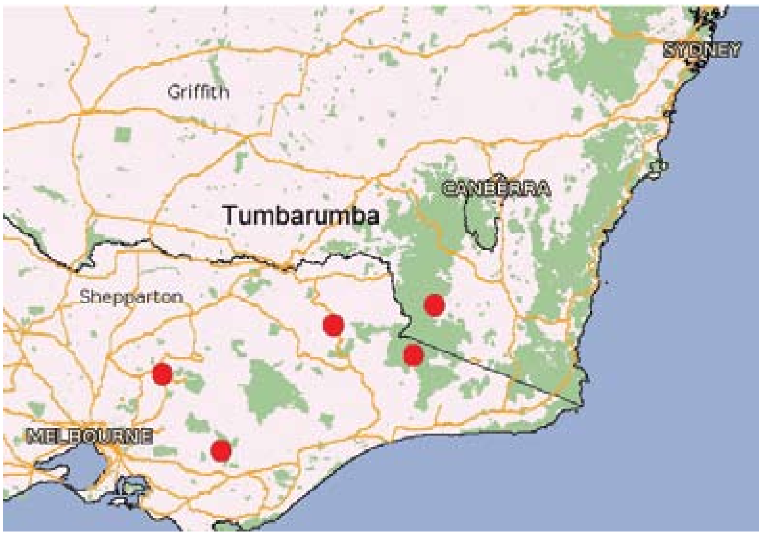

Figure 1. Collection sites (●) for *Eu. delegatensis* on the mainland

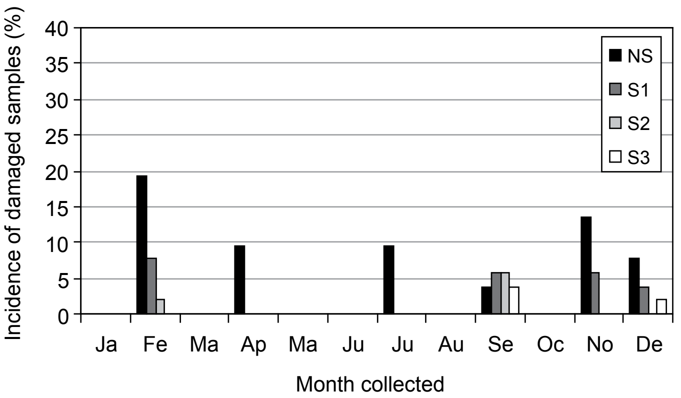

Figure 2. *Eu. grandis* lyctine susceptibility results in relation to month of sample collection. See text for key to the categories of damage (NS–S3).

This project was undertaken during drought conditions in much of the country, and drought may have reduced starch levels in trees of some species at some collection sites. Consequently, lyctine damage to sapwood may have been abnormally low in some specimens. Our assessment of 11 of the 16 timbers examined as lyctine susceptible would not have been affected in this way. The conditions under which the timbers were sampled may reflect future supply conditions, but whether in the longer term global warming will change relevant climatic conditions is not known.

Those timbers that are lyctine susceptible could be preservative treated using methods described and reviewed by Cookson *et al.* (1998) and Cookson (2004).

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References

Bamber, R.K. and Erskine, R.B. (1965) *Relationship of Vessel Diameter to* Lyctus *Susceptibility in some New South Wales Hardwoods*. Research Note No. 15, Division of Wood Technology, Forestry Commission of NSW, 18 pp.

Boland, D.J., Brooker, M.I.H., Chippendale, G.M., Hall, N., Hyland, B.P.M., Johnson R.D., Kleinig, D.A. and Turner, J.D. (1984) *Forest Trees of Australia*. Thomas Nelson and CSIRO, Melbourne, 677 pp.

Bootle, K.R. (1971) *The Commercial Timbers of New South Wales and their Uses*. Angus and Robertson, Sydney, 276 pp.

Bootle, K.R. (2005) *Wood in Australia. Types, Properties and Uses*. McGraw-Hill, Sydney, 452 pp.

Cookson, L.J. (2004) *Treatment Methods for the Protection of Hardwood Sapwood from Lyctine Borers.* CSIRO Technical Report No. 145. FWPRDC Project No. PN03.1313, 23 pp. http://www.fwpa.com.au/content/pdfs/PN03.1313.pdf.

Cookson, L.J., Scown, D.K. and McCarthy, K. (1998) Boron treatment methods for lyctid susceptible hardwoods growing in Tasmania. *The International Research Group on Wood Protection*. Document No. IRG/WP 98-30168, 12 pp.

Cookson, L.J., Carr, J., Chew, N. and Creffield, J. (2007) *Reassessment of Lyctine Susceptible Sapwood.* FWPRDC Project No. PN03.1313, 67 pp. http://www.fwpa.com.au/content/pdfs/new%20pdfs/PN03.1313_lyctine-report.pdf.

Creffield, J.W., Brennan, G.K., Chew, N. and N.-K. Nguyen (1995) Re-assessing the susceptibility of karri (*Eucalyptus diversicolor*) and jarrah (*E. marginata*) sapwood to attack by the powder post borer (*Lyctus brunneus*). *Australian Forestry* **58,** 72–79.

CSIRO Division of Forest Products (1950) Lyctus susceptibility list. *Proceedings 5th Forest Products Research Conference*, Melbourne, Topic 8B, 24 pp.

Fairey, K.D. (1975) *Lyctus Susceptibility of the Commercial Timbers Used in New South Wales*. Forestry Commission of NSW Technical Publication No. 19, 8 pp.

Humphreys, F.R. and Humphreys, N. (1966) Starch levels in flooded gum sapwood. *Australian Forest Research* **2,** 35–40.

Peters, B.C., Creffield, J.W. and Eldridge, R.H. (2002) Lyctine (Coleoptera: Bostrichidae) pests of timber in Australia: a literature review and susceptibility testing protocol. *Australian Forestry* **65,** 107–119.

Standards Australia (2005a) *Australian Standard 1604.1 Specification for Preservative Treatment. Part 1. Sawn and Round timber.* Standards Australia, Sydney, 41 pp.

Standards Australia (2005b) *Australian Standard 5604. Timber — Natural Durability Ratings.* Standards Australia, Sydney, 22 pp.

Standards Australia (2006) *Australian Standard 2796.2 Timber — Hardwood — Sawn and Milled Products — Grade Description.* Standards Australia, Sydney, 33 pp.